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Opportunities and barriers for international bioenergy trade

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ABSTRACT

Recently, the international trade of various bioenergy commodities has grown rapidly, yet this growth is also hampered by some barriers. The aim of this paper is to obtain an overview of what market actors currently perceive as major opportunities and barriers for the development of international bioenergy trade. The work focuses on three bioenergy commodities: bioethanol, biodiesel and wood pellets. Data were collected through an internet-based questionnaire. The majority of the 141 respondents had an industrial background. Geographically, two-thirds were from (mainly Western) Europe, with other minor contributions from all other continents. Results show that import tariffs and the implementation of sustainability certification systems are perceived as (potentially) major barriers for the trade of bioethanol and biodiesel, while logistics are seen mainly as an obstacle for wood pellets. Development of technical standards was deemed more as an opportunity than a barrier for all commodities. Most important drivers were high fossil fuel prices and climate change mitigation policies. Concluding, to overcome some of the barriers, specific actions will be required by market parties and policy makers. Import tariffs for biofuels could be reduced or abolished, linked to multinational trade agreements and harmonization (including provisions on technical standards and sustainability requirements).

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1. Introduction

In the past years, the international trade of various bioenergy commodities has grown rapidly, yet this growth is also hampered by a number of barriers. For example, the export of palm oil from South East Asian countries for the production of renewable electricity or biodiesel in Western Europe has been heavily criticized by NGOs (see e.g. Zakaria et al., 2009). Also the possible impacts of other internationally traded liquid biofuels (such as soy-based biodiesel and ethanol from sugarcane) have received increasing public (and largely negative) attention. On the other hand, international bioenergy trade can also offer opportunities for economic growth and socio-economic development for exporting countries, and may enable countries with few domestic biomass resources to meet their renewable energy targets, gain more fuel diversity and improve security of supply. The role of international trade in (especially liquid) biofuels has been discussed by several authors (see e.g. Dufey, 2007; EurActiv, 2009; Heinimö and Junginger, 2009; Junginger et al., 2006; Londo et al., 2010; Murphy, 2008; Oosterveer and Mol, 2010; Steenblik, 2007; De la Torre Ugarte, 2008; Zarrilli, 2008). However, to our knowledge no quantitative inventory of barriers and opportunities for bioenergy trade has been established so far based on stakeholder input. Also, these studies focus (almost) solely on liquid biofuels for transportation, neglecting a similarly rapidly growing international solid biomass fuel market. IEA Bioenergy Task 40[1] made an overview of barriers and opportunities for bioenergy trade in 2006 (Junginger et al., 2006), but given the rapid developments in this field, Task 40 decided to update this overview, of which this paper is the result.

The aim of this paper is to obtain an up-to-date overview of what market actors currently perceive as major opportunities and barriers for the current and future development of international bioenergy trade. The work focuses on three internationally-traded bioenergy commodities: bioethanol, biodiesel and wood pellets. The choice for these commodities is motivated by (a) a strong growth of trade in the past decade and (b) the expected further growth in coming years, due to current high and volatile fossil fuel prices and due to commitments to reduce GHG emissions and

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[1] IEA Bioenergy Task 40 was established under the International Energy Agency (IEA) Bioenergy Implementing Agreement in December 2003, and focuses on international bioenergy trade and its wider implications. It currently has 14 member countries. See for more information www.ieabioenergy.com and www.bioenergytrade.org.

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ambitious targets for biofuels and renewable electricity in e.g. the EU (EC, 2009).

For this paper, we do define 'barriers for international bioenergy trade' vary widely, mainly determined by what various stakeholders may perceive as a barrier to bioenergy trade. Principally, we define a bioenergy trade barrier as *any issue that either directly or indirectly hinders the growth of international trade of biomass commodities for energy end-use*. It is difficult to draw a clear line what (indirect) *trade* barriers are, and what *general* barriers hamper the use of biomass (irrespective of being traded or used domestically). For example, the current food-vs.-fuel debate (e.g. should vegetable oils be used as feedstock for biodiesel) affects biomass use in general, and is not discussed here as specific barrier to trade. Yet, this debate and resulting policy measures is likely to have direct impacts on the amount of ethanol, vegetable oils and biodiesel traded globally in the coming years. Also the global economic crisis is affecting bioenergy trade, but as it also affects biomass production, consumption, oil prices, etc., we do not list it as a 'trade barrier'. In the expert literature, 'trade barriers' are typically classified as tariff, para- and non-tariff barriers (UNCTAD, 2008). However, these definitions have neither been used for this paper nor for the questionnaire, as many of the market actors we target in the questionnaire may not be familiar with it, and such a detailed classification may deter participants from fully completing the questionnaire.

Describing barriers and opportunities is politically sensitive. An issue that market actors in one world region may see as a barrier to bioenergy, may be regarded as an opportunity by market actors in another region. Our aim is to make an overview of these different views, identify common viewpoints, and, where different views exist, thrive to describe these equally.

This paper is organized as follows: Section 2 describes the methodology and data collection. In Section 3, a brief overview of the production and trade of the biomass commodities investigated is presented. Next, an overview of the bioenergy trade barriers and opportunities is given in Section 4, subdivided for each topic into a general review of the literature and an overview of the survey results. These are summarized and discussed in Section 5.

2. Methodology and data collection

To obtain input from market actors, an online questionnaire was designed. Based on a literature survey, a number of categories of trade barriers were defined and used in the questionnaire. These categories are presented and described further in Sections 4.2–4.7, along with concrete examples. They focus on three selected bioenergy commodities: bioethanol, biodiesel and wood pellets. For each category, a number of questions (with a number of predefined possible answers) were asked. The questionnaire also contained two free sections: one where stakeholders could indicate what additional barriers they had encountered in bioenergy trade, and a second section where they could highlight the opportunities they saw for the future. These are discussed in Sections 4.8 and 4.9, respectively. The original questionnaire and all answers to open questions can be found in a background report (Junginger et al., 2010).

The questionnaire was designed and tested internally with the members of IEA Bioenergy Task 40 until the end of 2008. After this, the questionnaire was open and openly advertised on the Task 40 homepage between February 12th and July 24th 2009. It was mainly aimed at industry actors (e.g. producers, traders, consumers and industry associations) and their view on opportunities and barriers for bioenergy trade. To a lesser extent, the questionnaire was also sent to policy makers, NGOs and other experts from academia and other institutions. To obtain a comprehensive market overview, the questionnaire was sent to all contacts of the Task 40 national team members. Many of the major bioethanol producers and consumers (Brazil, US, and many EU countries) are all members of Task 40. In addition, the invitation was sent to market actors outside the Task 40 member countries, which have considerable trade volumes, e.g. Malaysia, Indonesia, Argentina, etc. for biodiesel and several Eastern European countries for wood pellet production. Furthermore, several bioenergy/industry associations in these regions were contacted and asked to distribute the questionnaire to their members. In addition, to reach a large amount of stakeholders, cooperation was sought with UNCTAD and the United Nations Industrial Development Organization (UNIDO). UNIDO was able to send out the questionnaire to almost 1000 biomass producers and traders across the world.

3. Overview of the commodities investigated: bioethanol, biodiesel and wood pellets

In this section, a brief overview of the production and trade of the biomass commodities investigated is presented. In Table 1, a summary is shown for bioethanol, biodiesel and wood pellets. In this section all data on production, consumption and trade refer to the year 2008 unless stated otherwise.

3.1. Bioethanol

Bioethanol (ethyl alcohol) is a liquid biofuel which is currently mainly produced from organic feedstocks containing sugars—such as sugarcane, corn, wheat, sugar beet or molasses. Fuel bioethanol is traded under HS code 2207, which covers denatured and undenatured alcohol. Both can be used as fuel ethanol, but denatured ethanol is often used as solvent (UNCTAD, 2008). The term 'bioethanol' is used to indicate that ethanol was produced from organic feedstocks. Bioethanol can also be processed further to ETBE, which can be blended with gasoline as a biofuel. However, within the frame of this study we only analyze the trade of bioethanol. In 2008, world

Table 1
Overview of global production and trade of the major biomass commodities in 2008.

	Bioethanol[a]	Biodiesel[a]	Wood pellets[b]
Global production in 2008 (million tonnes)	52.4	13.1	11.5
Global net trade in 2008 (million tonnes)	2.8 (min) – 3.1 (max)	2.4	Approx. 4
Main exporters	Brazil	United States, Argentina, Indonesia and Malaysia	Canada, USA, Baltic countries, Russia
Main importers	USA, Japan, European Union	European Union	Belgium, Netherlands, Sweden, Italy

[a] Based on Lamers et al. (submitted for publication).
[b] Based on Sikkema et al. (submitted for publication), Bradley et al. (2009) and Spelter and Toth (2009).

fuel ethanol *production* amounted to 52.4 million tonnes, more than doubling the 23.7 million tonnes produced in 2004 (Lamers et al., accepted for publication; Martinot and Sawin, 2009). The two leading ethanol producers were the United States (26.8 million tonnes) and Brazil (21.3 million tonnes), representing 91% of the world production (FAPRI, 2009). Regarding *consumption*, the US consumes more bioethanol as transportation fuel than any other country in the world. In 2008, total consumption was about 28.4 million tonnes, of which about 4.6% was imported. Brazilian fuel bioethanol consumption amounted to approximately 16.5 million tonnes. In the EU, total consumption for transportation was 2.6 million tonnes, the largest users being France, Germany, Sweden and The Netherlands (EurObserv'ER, 2009). Data related to fuel bioethanol *trade* are imprecise on account of the various potential end-uses of ethanol (i.e. fuel, industrial use and beverage use) and also because of the lack of proper codes for biofuels in the HS. An overview of trade flows is shown in Table 1. For a detailed and comprehensive overview of global ethanol trade, see Lamers et al. (accepted for publication).

3.2. Biodiesel

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Typical feedstocks for biodiesel are vegetable oils such as rapeseed oil, soybean oil, palm oil, etc. or animal fat (tallow). Biodiesel is used in standard diesel engines (mostly blended with fossil diesel) and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. World biodiesel *production* increased sixfold from about 1.8 million tonnes in 2004 to about 10.6 million tonnes in 2008 (Martinot and Sawin, 2009). The EU produces about two-thirds of this, with Germany, France, Italy and Spain being the top EU producers. European biodiesel production rose to 7.8 million tonnes in 2008, equivalent to a 35.7% increase compared to 2007 and 2008. However, EU production declined 7% in 2009 because of strong competition from abroad (FAPRI, 2009). Other main biodiesel producers include the United States, Argentina and Brazil. Biodiesel *consumption* in the EU amounted to about 9.2 million tonnes (EurObserv'ER, 2009), with Germany alone consuming 2.9 million tonnes. While policies aimed at stimulating the use of biodiesel have been put in place in several other countries outside the EU, actual use remains still limited. International biodiesel *trade* (under HS Codes 38249099 and 38249029) has been increasing strongly since 2005. According to the European Biodiesel Board (EBB), US gross exports have increased from negligible levels in 2005 to about 1.4 million tonnes in 2008 (EBB, 2009c) compared to net export about 1.175 million tonnes, FAPRI, 2009). Also Argentine exports to EU increased strongly from 70 000 tonnes in 2008 to an estimated 1 million metric tonnes in 2009 (EBB, 2009b). Brazil (a major biodiesel producer) does not export biodiesel in any significant quantities because of a domestically mandated renewable fuel requirement that 3% of its biodiesel must be included in its diesel pool (Taylor, 2009). For a detailed and comprehensive overview of global biodiesel trade, see Lamers et al. (accepted for publication).

3.3. Wood pellets

Wood pellets are a type of wood fuel generally made from compacted sawdust. They are usually produced as a byproduct of sawmilling or other wood transformation activities. In past years, increasingly also round wood and wood chips are used as feedstock. Wood pellets typically have a low moisture content (below 10%) and a high energy density compared to many other solid biomass types. These properties allow efficient storage and long-distance transport. Wood pellets can be used on various scales, ranging to combustion in stoves for heating of households (e.g. in Austria, Italy, Germany and the US) to (co-)firing in large scale coal power plants (mainly in the Netherlands and Belgium (Sikkema et al., 2010a). Since the 1st of January 2009, official export and import figures on pellets are published by Eurostat using the CN product code "44.01.3020", defined as "sawdust and wood waste and scrap, agglomerated in pellets" (Sikkema et al., accepted for publication). Production, consumption and trade have grown strongly within the last decade: before 1998, pellets were only used on a marginal scale, mainly in Scandinavian countries and Austria. *Production* mainly takes place in Europe and North America. In 2008, as a rough estimate, about 8 million tonnes of pellets were produced in 30 European countries, compared to 1.8 million tonnes in the US and 1.4 million tonnes in Canada. Following Sikkema et al. (accepted for publication), the European *consumption* for 2009 is expected to be about 8.5 million tonnes. The largest EU consumers are Sweden (1.8 million tonnes), Denmark, the Netherlands, Belgium, Germany and Italy (all roughly one million tonnes). Also the US is a major consumer of wood pellets. The first intercontinental wood pellet *trade* has been reported in 1998, for a shipment from British Columbia (Canada) to Sweden. Since then, Canada has been a major exporter to Europe (especially Sweden, the Netherlands and Belgium) and to the US. In 2008, the US started to export wood pellets to Europe, while Canadian producers started to export to Japan. Total imports of wood pellets by European countries in 2009 were estimated to be about 3.8 million tonnes, of which about half of it can be assumed to be intra-EU trade. Total export is estimated at 2.7 million tonnes, predominantly intra-EU trade (Eurostat, 2010).

4. Bioenergy trade barriers—a review of literature and stakeholder views

4.1. General survey response

In total, 141 participants completed the questionnaire, although not every participant responded to each question. Typically, between 80 and 110 respondents provided answers to the individual questions. The majority (54%) of participants had an industrial background (including producers, consumers and traders), with other contributions from NGO's (10%), scientists (15%), policy makers (8%) and other groups (13%). When asked about their expertise, 50% of the participants indicated that they had specific expertise on wood pellets trade, 24% were experts for biodiesel trade, 14% on bioethanol trade and 12% indicated to have general expertise. Regarding the geographical distribution of the respondents, more than two-thirds were from (mainly Western) Europe, with other minor contributions from North America (almost exclusively from the US), South America (Brazil and Argentina), Africa (mainly South Africa) Asia (amongst others Malaysia, Indonesia, South Korea and Japan) and a single participant from Australia. In the following sections, each of the trade barrier categories formulated will be shortly described based on a literature review, followed by an overview of the responses and particular comments by individual respondents.

In the following sections, the survey results are presented for each of the possible trade barriers. In the graphs displaying the results, a differentiation is made between the answers given by all respondents, and the answers provided by (self-indicated) experts for the specific commodity (bioethanol, biodiesel or wood pellets).

4.2. Impact of national/regional protectionist policies and tariff barriers

4.2.1. Literature review

To mitigate the generally higher production costs of liquid biofuels, governments in many countries have supported domestic production and use through policy incentives, such as tax exemptions and subsidies. In some cases, these support schemes may shield domestic producers from foreign competition and hindering international trade. These incentives are often geared towards the promotion of domestic agricultural feedstocks and interests, rather than the promotion of biofuels with economic, energetic or environmental advantages. In other cases, policy incentives can (directly or indirectly) support the export of biofuels. Importantly, support measures in developed countries have implications for developing country producers by reducing their competitiveness, creating global inequalities and distorting international trade.

In principle, three different mechanisms can be distinguished:

(1) *Measures to promote domestically produced biofuels over imported biofuels.* For example, in France, tax exemptions are available only for biofuels that are both produced and sold in the French market. Producers from other EU countries are thus excluded, leaving them at a competitive disadvantage (Euractiv, 2009). Similarly, Steenblik (2007) reports that several US states provide their own volumetric subsidies to support in-state production of bioethanol or biodiesel at rates equivalent to €0.04 per litre or more. Additionally, companies that blend biodiesel (excluded imported biodiesel) into diesel fuel benefit from a Volumetric Biodiesel Tax Credit of $1 per gallon (Koplow, 2009).

(2) *Import tariffs.* Tariffs are applied on *bioethanol* imports by both by EU (0.192€ per litre) and the US (0.1427 US$ per litre and an additional 2.5% *ad valorem*). Several preferential trade arrangements concluded in the past by the EU with developing countries foresaw either no duties or reduced tariffs for ethanol, including the Generalized System of Preferences (GSP, which applies to many developing countries), the Cotonou Agreement (African, Caribbean, and Pacific countries; or ACP Group), the Everything But Arms (EBA) initiative (for developing countries), among others. For a comprehensive description of these systems, see Junginger et al. (2010) and Oosterveer and Mol (2010). In general, the most-favoured nation (MFN) tariffs range from roughly 6% to 50% on an *ad valorem* equivalent basis in the OECD, and up to 186% in the case of India (Steenblik, 2007).

Biodiesel used to be subject to lower import tariffs than bioethanol, ranging from 0% in Switzerland to 6.5% in the EU and the USA. Tariffs applied by developing countries are generally between 14% (e.g. Brazil) and 50% (Steenblik, 2007). However, over the course of 2007 ad 2008, the above-mentioned biodiesel tax credit had led to massive exports of biodiesel from the US to the EU. In March 2009, the European Commission approved a temporary imposition of anti-dumping and anti-subsidy rights on American biodiesel imports, following a complaint lodged by the European Biodiesel Board (EBB). On 7th July this decision was extended by the Council of Ministers for a period of five years. These fees stand between €213 and €409 per tonne (EurObserv'ER, 2009). Most recently, in November 2009, the EBB claimed that circumvention patterns had materialized five months after the imposition of the EU duties, either via triangular trade with third countries based on fraudulent declarations of origin, or through blends (at a B19 or lower level) specifically designed to circumvent the EU anti-dumping and countervailing duties in force. (EBB, 2009a). Against the background of these practices, the EBB General Assembly decided to proceed with the lodging of an anti-circumvention complaint to the EU trade authorities.

(3) *Export tariffs* can also have an impact on trade of biomass commodities. As a first example, in Argentina, a differential export tax is in place between soy oil (32%) and biodiesel (20%). The Argentine Renewable Energy Chamber argues that this is a "very simple way to create investment incentives that generate more complex and high-paying jobs" (CADER, 2009), while according to the EBB (2009b), it "creates a clear distortion, as it creates an artificial incentive for the production and export of the finished product biodiesel rather than its raw material (soybean oil)", which it considered unfair competition compared to European biodiesel. As a second example, the above-mentioned volumetric biodiesel tax credit was probably not intended as an export subsidy, but certainly did spur exports towards the EU.

A more comprehensive overview of these policies is provided by Junginger et al. (2010). Summarizing, on basis of the literature overview, it seems that tariff barriers are particularly important for liquid biofuels (active for decades for ethanol, and only relatively recently for biodiesel), while no tariff barriers for wood pellets (or other solid biofuels) were found in the literature.

4.2.2. *Survey results*

The respondents were asked whether tariffs are (or can be) a barrier for the bioethanol, biodiesel or wood pellets, and whether there are also cases where tariffs may stimulate trade. The answers are shown in Fig. 1.

For wood pellets, all open-text contributions indicated that there are indeed no import or export tariffs in existence. But, as expected from the literature review, a majority of (informed) respondents thought that tariff barriers for ethanol and (to a somewhat lesser extent biodiesel[2]) should be considered a (major) trade barrier.

Regarding the bioethanol trade, a Swedish respondent remarked "Especially the development of the Flexifuel car market (in Europe) is strongly inhibited by the customs on sugarcane ethanol in the EU. A lower import tariff on bioethanol would be a greater competitor to gasoline. The EU focuses on not competing with European ethanol production, when the focus should be replacing imported oil products". Similarly, a Brazilian respondent remarked: "The ethanol exports are very limited in major consumption markets (USA and EU) due to trade barriers. The CBI agreement, the way which Brazilian exports go to the USA, does not make any economic or environmental sense, or the corn ethanol program in USA. If we had free ethanol trade, we would have massive GHG savings."

For biodiesel, a more differentiated picture was found: while still about 45% of all experts thought import tariffs for biodiesel were major or minor barriers for trade, views on this matter differed. A Malaysian producer stated: "By creating Trade Barriers through Import/Export Tariffs, the market for Biodiesel is completely distorted. More expensive and not so environment friendly sources of vegetable oils are used in preference to more cost effective and more environment friendly Biodiesel. In addition when land is scarce for cultivation high yielding crops like Oil Palm have a much better comparative advantage and should be allowed to trade in an open market without trade barriers." An Argentinean remarked that next to import tariffs, also the Argentinean export tariffs were a major barrier to biodiesel trade.

An Italian producer on the other hand defended the use of import tariffs: "The case of the US 'splash and dash' practice for biodiesel well explains how export subsidies might affect biofuel

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[2] Note that the situation for biodiesel changed significantly whilst the questionnaire was open, as the EU initiated anti-dumping and countervailing measures regarding US Biodiesel imports on March 12th 2009, and confirmed them in July 2009.

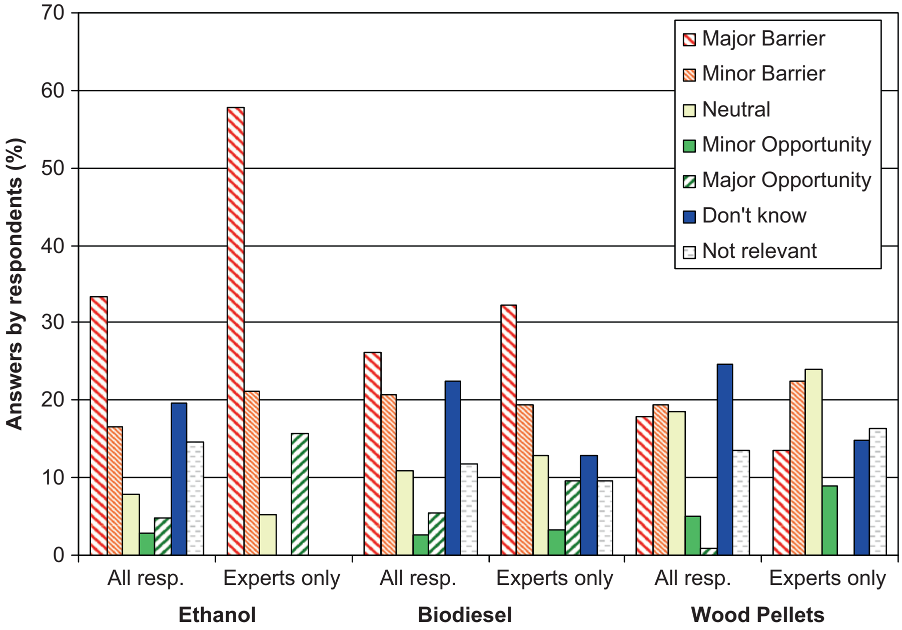

Fig. 1. Overview of questionnaire responses on import/export tariffs.

international trade. I think that this kind of market distortion should be avoided in order to allow a fair biofuel chain development in all different market. The EU issue to undertake a balanced approach between import and internal production of biofuel should be pursued by means of fair tariff and trade procedures and at the same time by allowing the development of national biofuels chain with a special care for sustainable local agricultural production."

The EBB formulated a comprehensive contribution to this topic (see Junginger et al., 2010 for all full answers of respondents). They stated "…on the one hand, import tariffs for biodiesel do not represent a trade barrier, especially within the EU, where only a 6.5% *ad valorem* duty is levied on biodiesel imports. The fact that the EU biodiesel market is not overly protected has been clearly illustrated by the surge of so called US "B99" biodiesel exports to the EU in 2007 and 2008. More than 1.05 million tonnes (2007) and almost 2 million tonnes (2008) of heavily subsidized and dumped US biodiesel were exported to the EU, until anti-dumping and countervailing measures were eventually imposed by the EU"… "These measures against US B99 were not at all a protectionist move but they merely contributed to re-establish the level-playing field that EU biodiesel producers can legitimately enjoy" (see Junginger et al., 2010 for further details).

4.3. *Impact of technical standards/technical barriers to trade*

4.3.1. *Literature review*

Technical standards describe in detail the physical and chemical properties of fuels. Regulations pertaining to the technical characteristics of liquid transport fuels (including biofuels) exist in all countries. These have been established in large part to ensure the safety of the fuels and to protect consumers from buying fuels that could damage their vehicles' engines. Two types of technical regulations affect trade in biofuels: maximum percentages of bioethanol or biodiesel which can be mixed with petroleum fuels in the blends commercially available; and regulations pertaining to the technical characteristics of the biofuels themselves. For the latter type, over the course of 2007 experts from standards developing organizations (SDOs) in the United States, Brazil and the European Union (EU) reviewed standards for bioethanol and biodiesel, including the technical documents produced by the American Society for Testing and Materials (ASTM), the Associação Brasileira de Normas Técnicas (ABNT), and the European Committee for Standardization (CEN). They jointly authored a report (Tripartite Task Force (2007) that identified standard 16 specifications for bioethanol and 24 for biodiesel, and ranked them in three categories:

- Specifications that are similar among all three regions and can be considered compatible;
- Specifications with differences that could be aligned in the short term (< 12 months);
- Specifications for which fundamental differences exist and are deemed irreconcilable.

For bioethanol, the report found 9 of the 16 bioethanol specifications to be 'in alignment.' All but one of the remaining specifications could be aligned in the short term. Despite modest differences, the report concluded that existing specifications present no impediment to global trade in bioethanol.

For biodiesel, however, only 6 of the 24 biodiesel specifications are considered 'in alignment', while nine factors are deemed irreconcilable. This difference is explained by the fact that bioethanol is a single chemical compound (independently from which feedstock it is produced), whereas biodiesel is derived from several types of feedstocks that cause variations in the chemical composition of the biodiesel (e.g. different chain lengths, varying number of double bonds), which influences its performance characteristics. The tripartite report suggests that many differences can be dealt with by blending various types of biodiesel to create an end-product that meets regional specifications for fuel quality and emissions. Other sources (Euractiv, 2009, Jank et al., 2007, Oosterveer and Mol, 2010) have argued that by fixing, for example, maximum levels of iodine for vegetable oils used in the EU biodiesel standard (DIN EN 14214), the EU is limiting the use of biodiesel produced soy oil (and to a lesser extent palm oil) and is favoring rapeseed, the main European biodiesel feedstock.

For wood pellets, for the EU, the CEN/TC 335 working group developed biomass standards to describe all forms of solid biofuels within Europe, including wood chips, wood pellets and briquettes, logs, sawdust and straw bales. Specifically for wood pellets, the CEN/TS 14961 standard divides wood pellets in various classes regarding size, ash content, mechanical durability, etc. Next to this, various European countries have developed their own quality standards, e.g. Austria (Önorm M7137), Germany (DIN51731) and Italy (Pellet Gold). These pellet standards are mainly aimed at pellet use for non-industrial small-scale heating, where e.g. ash content is critical. Industrial wood pellets (e.g. for co-firing with coal) are often traded without the use of a widely-accepted technical standard. As an example, GDF-SUEZ/Electrabel utility has developed its own standard for pellets imported for power plants in Belgium (Marchal et al., 2009).

4.3.2. Survey results

The respondents were asked whether standards for ethanol, biodiesel or wood pellets may impede or facilitate international trade. As can be seen in Fig. 2, about 45% of the ethanol experts and 40% of biodiesel experts thought that technical standards were a minor or major barrier to trade. However, for biodiesel, also more than 25% thought that a technical standard for biodiesel would actually create opportunities for trade. In comparison, regarding wood pellets, more than 50% of the experts thought that the establishment of an internationally accepted technical industrial wood pellet standard would be a (major) step to enhance the global trade.

In general, all respondents recognized that technical standards are a basic requirement for large-scale international trade. This was indicated for bioethanol, biodiesel and wood pellets. However, as one of the respondents from Indonesia remarked: "developed countries must be reasonable to set a standard specifically for products from developing countries, because lack of technology and capital. Unless developed countries share the technology and investment, it will be difficult for developing countries to produce bioethanol or biodiesel to meet international high quality standard". On the other hand, a Belgian respondent argued that "Technical standards regulating biodiesel quality and specifications in the different regions of the world does not represent an obstacle to trade, despite some regional differences". This has been acknowledged by the EU/US/Brazil Tripartite Task Force in its report on internationally compatible biofuels standards Tripartite Task Force (2007). More specifically, the report states that "While some methods, test parameters, or parameter limit values are not currently aligned, their non-alignment may not have much of an impact if biodiesel made in one region is destined for use in another region". The fact that biodiesel standards do not represent an obstacle to trade has been further evidenced by the fact that US B99 biodiesel has been massively exported to the EU in 2007 and 2008, despite some minor differences between the ASTM and EN biodiesel standards."

For wood pellets, it was mentioned that technical standards will improve confidence in the market and should therefore increase trade. Also, a market actor remarked that there is "… a great deal of uncertainty regarding origin and quality of wood pellets. A strong and commonly used standard may help to remove this uncertainty". Furthermore, it was pointed out that "standards reduce transaction costs (reduce the cost of information) and thereby facilitate trade". In addition, respondents raised also (slight) concerns: multiple sets of standards which are not aligned could hamper trade. Also, a too strict standard (e.g. regarding ash content) could cause higher costs for producers, and as (wood pellet) markets are still in a developing stage, standards might hamper the development by blocking out opportunities.

4.4. Sustainability criteria and certification systems for biomass and biofuels

4.4.1. Literature review

In recent years, sustainability requirements have increasingly been imposed (or are considered) on either (a) feedstocks (such as palm oil) or (b) final products. Such requirements relate to non-product-related processes or production methods (PPMs). The different standards and regulations under consideration are discussed in more depth by van Dam et al. (2008, 2010), and can be summarized in three categories:

1. Private-sector, voluntary business-to-business standards. Examples for **wood pellets** are the Green Gold Label initiated by Essent, or the GDF-SUEZ/Electrabel label by SGS and

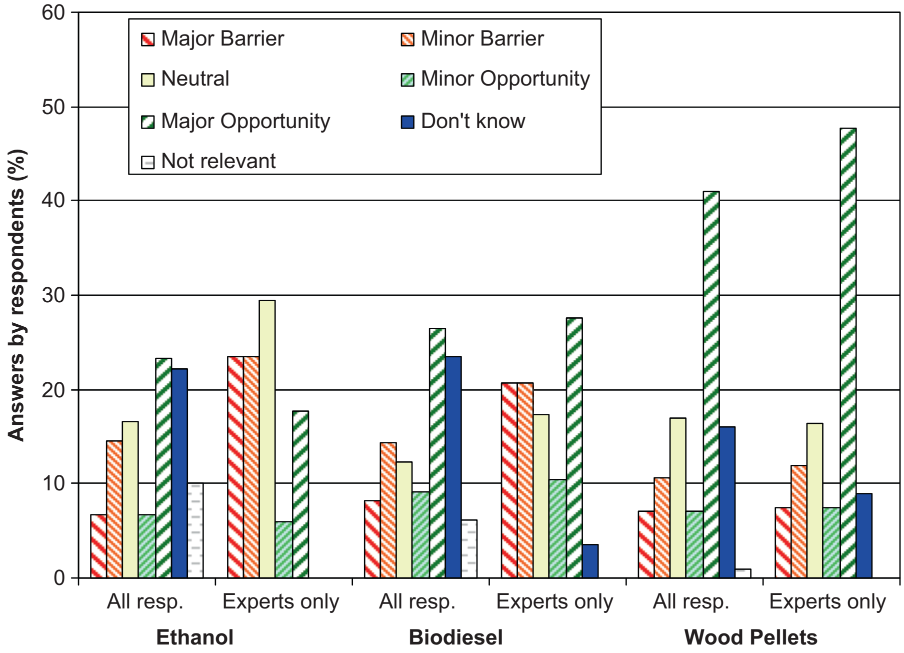

Fig. 2. Overview of questionnaire responses on technical standards.

Laborelec (Marchal et al., 2009; van Dam et al. 2008; Ryckmans et al., 2006). For **bioethanol**, the 'verified sustainable ethanol initiative' launched by Sekab and UNICA is a clear example of a voluntary industry standard.
2. Voluntary standards, initiated by governments or other private initiatives, which are often implemented in connection with positive labels, and are intended to reward (through the higher prices expected to be paid by concerned consumers) performance beyond the norm. Examples of other initiatives that are the Roundtable on Sustainable Palm Oil (RSPO), the Roundtable on Responsible Soy (RTRS), the Roundtable on Sustainable Biofuels (RSB) and the Global Bioenergy Partnership (GBEP) (see van Dam et al., 2010 for a comprehensive overview). Such voluntary standards may be seen as opportunity to differentiate a product from that of competitors in the market.
3. Regulations linked to tax exemptions, subsidies or other policy instruments which make the eligibility of a biomass product dependent on certification at some stage of its production process or processing. Examples for **liquid biofuels** are the Renewable Transport Fuel Obligation (RTFO) in the UK, the German Biofuel Quota Law, the Energy Independence and Security Act (EISA) in the United States, and the European discussion on the draft fuel quality directive and the renewable energy directive (RED) (see van Dam et al., 2010 for an overview). For **wood pellets**, for example Walloon authority imposes that each supplier undergoes an audit within six months for certification of imported biomass, which examines the sustainability of the wood sourcing as well as detail of the energy balance (through an energy audit including GHG emissions) of the whole supply chain (Marchal et al., 2009; Ryckmans et al., 2006).

In 2009, standardization organizations such as CEN and ISO have also announced to develop sustainability standards (see CEN, 2010; ISO, 2010).

In the past years, binding legislation on sustainability criteria did barely exist, and different parties have come up with voluntary standards. With the recent publication of sustainability criteria in the renewable energies directive (RED) (European Commission, 2009) *for liquid transport fuels*, this situation has changed. The directive notably provides requirements for greenhouse gas emission reductions, the biofuels in question must not be produced from raw materials being derived from land of high value in terms of biological diversity or high carbon stocks. Furthermore, the Commission shall present a report every two years on the impact of increased demand for biofuel on sustainability in the EC and in third countries, and on the impact of the EU biofuel policy on the availability of foodstuffs at an affordable price, in particular for people in developing countries, and on wider development issues. Also in the USA, the Renewable Fuel Standard (RFS) – included in the EISA – provides provisions on the promotion of biofuels (especially cellulosic biofuels). EISA mandates minimum GHG reductions from renewable fuels, discourages use of food and feed crops as feedstock, permits use of cultivated land and discourages (indirect) land-use changes.

On the other hand, for *solid* biomass and biogas for heat and electricity, a recent report by the European commission (European Commission, 2010) stated on the other hand that binding criteria would impose substantial costs on European economic actors, bearing in mind that at least 90% of biomass consumed in the EU comes from European forest residues and by-products of other industries. Hence, the report concluded that more detailed legislation is not necessary.

With these developments, it is likely that – at least for the European Union and the USA – sustainability criteria will have a potentially much larger impact on trade of liquid biofuels compared to the trade of solid biomass.

The topic of sustainability certification and impacts on trade is discussed extensively by van Dam et al. (2010). For the sake of brevity, we only briefly discuss some concerns:

- With current developments by the European Commission, different European governments, several private sector initiatives, initiatives of round tables and NGO's, there is a real risk that on the short term a multitude of different and partially incompatible systems will arise. With too many schemes in operation, each including a different set of requirements without clear rules for mutual recognition, such a multitude of systems could potentially become a major barrier for international bioenergy trade instead of promoting the use of sustainable biofuels production.
- Additionally, lack of internationally systems may cause market distortions. For example, if different countries or world regions impose different GHG reduction requirement, this may effectively exclude specific region-crop combinations for stringent GHG reduction requirement, causing that these products then are exported to regions with less severe requirements.
- Criteria, especially related to environmental and social issues, could be too stringent or inappropriate to local environmental and technological conditions in producing developing countries, and will only allow farmers from developed countries to meet the criteria.
- Linked to strict sustainability criteria, the costs for (a) implementing measures to meet the sustainability criteria, and (b) monitoring and certification of the biomass produced may worsen the economic competitiveness, especially of small farmers in developing countries. Exploratory studies by Smeets et al. (2008) and Smeets and Faaij (2010) indicate that production costs in Brazil for ethanol from sugarcane and may increase to 36% (ethanol from sugarcane) or 42% (eucalyptus wood chips), especially due to strict environmental criteria.
- There is a danger furthermore, overly detailed rules that lead to compliance difficulties. On the other hand, the fear of many NGO's is that less-strict standards are so general that they become meaningless.
- For biofuels certification schemes sponsored by governments, certification is in most cases linked to tax breaks and other incentives, or it is the precondition for biofuels to be counted towards national or regional utilization targets. Contrary to other certification and labeling initiatives that are meant to influence consumers and help them distinguishing products on the market on the basis of certain characteristics, biofuels certification is linked to important financial benefits or to the capacity to fulfill national utilization targets. These elements make certification an increasingly important issue, including in international trade. Differentiating products, including biofuels, on the basis of how they have been produced and of their impact through their life cycle remains, however, a complex endeavor, both from practical and legal points of view.
- Other issues currently debated are e.g. the inclusion of indirect land use change (iLUC) and food security. These issues cannot easily be tackled by certification systems but require wider land-use management and planning (van Dam et al., 2010).

4.4.2. Survey results

The respondents were asked how sustainability criteria for bioenergy commodities could influence bioenergy trade. This question greatly divided the respondents, as can be seen in Fig. 3. Especially for ethanol, there is an extreme difference

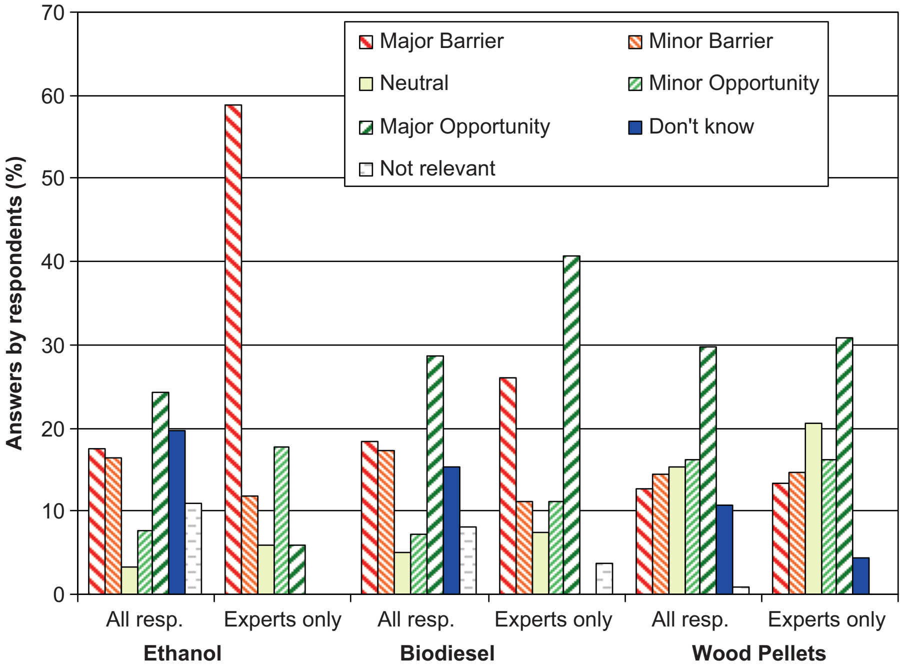

Fig. 3. Overview of questionnaire responses on sustainability criteria.

between the expectation of the experts, where almost 60% considered it a major barrier, and the total of all respondents, where less than 20% expected this to be major barrier. Also, it is remarkable that both for biodiesel and wood pellets, the majority of experts thought that sustainability criteria would be an opportunity for trade. Yet, 25% of all biodiesel experts thought that they were a major barrier—demonstrating that opinions were quite divided.

The differing views may largely be explained by the fact that at the moment, there is no universally accepted definition of 'sustainable biomass'. Many respondents agreed that biomass has to be produced sustainably, but it strongly depends on how sustainability criteria are formulated. If too strict, or too many different standards, sustainability criteria may become a major hindrance for trade (for all answers, see Junginger et al., 2010).

A Brazilian ethanol expert thought that sustainability criteria are not working yet as a major trade barrier, but he feared that the EU Renewable Energy Directive (RED) might create a major trade barrier. At the same time, he recognized that they might help the producers to have a cleaner production line. Also a biodiesel expert from Malaysia expected that sustainability criteria will be used as non-tariff barriers. He pointed out that (i) sustainability standards are required for biofuels but not for other, similar commodities, with similar environmental, social and GHG impacts, (ii) there is continuing future uncertainty due to ongoing review provisions of the EU RED and (iii) it is unclear which standards, certification and Chain of Custody procedures will be applied. This view is shared by more organizations from Malaysia and Indonesia: in December 2009, the Malaysian Palm Oil Council (MPOC) announced that Malaysia and Indonesia, the world's leading palm oil producers, and other palm oil producing countries may group together and file a case to the World Trade Organization (WTO) against the European Union (EU) for introducing sustainability criteria in the RED. In their view, the EU directive seeks to restrict the import of palm oil for biofuel usage in Europe in favor of the heavily subsidized home-grown rapeseed oil (MPOC, 2009).

The EBB conceded that ensuring the sustainability of bioenergy and biomass production is a legitimate concern, but pointed out that the way in which sustainability requirements are implemented at international level can represent a significant barrier to fair international trade. In the view of EBB, the bottom line is that sustainability criteria should be implemented in a transparent, horizontal, cost-effective and WTO-compatible way.

Some wood pellet experts see sustainability criteria as a way to differentiate themselves from liquid biofuels. They remarked that "proof of sustainability of the chain will help wood pellets to be distinguished from other biofuels which have in the past lead to major concerns of the sustainability of biomass in general". Another expert thought that "Governments are reluctant to subsidize the use of wood pellets because of sustainability issues. A sustainability standard might help. Major users will only use wood pellets that are (internationally) certified, for (1) trading reasons (2) corporate social responsibility reasons and (3) getting subsidies." Furthermore, an expert remarked: "…more clarity on sustainability would actually boost biofuels trade; the lack of an agreement on what's sustainable and what's not is hampering the development and use of new products." Another expert worried that "Certifying and monitoring sustainability criteria costs money per ton wood pellets traded. Unless linked to subsidies, this will result in less buying power from EU". Regarding the administrative burden, a concern was that "sustainability criteria could make it very difficult for wood pellet producers to comply with at the short run. It's another regulation to worry about and this is very time consuming to sort out. This hinders the continuity of trade."

4.5. Logistical barriers

4.5.1. Literature review

One of the problems of logistical barriers is a general lack of technically mature pre-treatment technologies in compacting biomass at low cost to facilitate transportation. While densification technology has recently improved significantly e.g. for wood pellets, this technology is only suitable for certain biomass types. Also, the final density per cubic meter is still far less than e.g. oil given the nature of biomass. Pyrolysis or torrefaction may be a possible pre-treatment option, but still there is a need to demonstrate it on a commercial scale. In the case of the import of liquid biofuels (e.g. bioethanol, vegetable oils, biodiesel), this is not an issue, as the energy density of these biofuels is relatively high.

When setting up biomass fuel supply chains for large-scale biomass systems, logistics are a pivotal part in the system (Cherubini et al., 2009; Frombo et al., 2009; Junginger et al., 2001). Various studies have shown that long-distance international transport by ship is feasible in terms of energy use and transportation costs (e.g. Sikkema et al., 2010a, Magelli et al., 2009; van Dam et al., 2009) but availability of suitable vessels and meteorological conditions (e.g. winter time in Scandinavia and Russia) need be considered. Availability of vessels is of course closely linked to international shipping rates of dry bulk (for wood pellets) or dedicated tankers for bioethanol and biodiesel. Shipping rates have been fluctuating strongly in the past years—from 2005 to 2007, and tripling of dry bulk rates were reported for Panamax vessels (Bradley et al., 2009). Shipping rates determine especially for (western Canadian) wood pellets a large percentage of the total costs delivered to the end user in Europe. Harbor and terminal suitability to handle large biomass streams can also hinder the import and export of biomass to certain regions. The most favorable situation is when the end user has the facility close to the harbor avoiding additional transport by trucks.

Local transportation by truck or train (both in biomass exporting and importing countries) may be also a high cost factor, which can influence the overall energy balance and total biomass costs. For example, in Brazil, new sugarcane plantations are considered in the Center-West, but the cost of transport and lack of infrastructure to transport bioethanol to the demand centers (either domestically or for export) can be a serious constraint. Due to the increasing export demand for bioethanol, Brazil is encouraging major investments in dedicated long-distance bioethanol pipelines and terminals. For wood pellets, further growth of transport of wood pellets from the hinterland of British Columbia to the Ports of Vancouver and Prince Rupert by train may be seriously hampered by limited logistical infrastructure (e.g. single rail tracks).

The lack of significant volumes of biomass can also hamper logistics. In order to achieve low costs, large volumes need to be shipped on a more regular basis. Only if this can be assured, there will be forthcoming investment on the supply side (e.g. new biomass pellet factories) at this will reduce costs per tonne significantly through economies of scale. The bulky nature of biomass fuels and the relatively low value per unit restricts availability of suitable areas for handling these fuels in busy ports. On the other hand, this bulky nature in combination with high demand for specific biomass streams means that the present capacity (incl. storage, handling equipment, etc.) of some harbors is fully utilized. A further increase in biomass handling would require specific investment.

4.5.2. Survey results

The respondents were asked how important logistical barriers are for the development of international bioenergy trade. Many respondents replied that logistics are just a challenge, which has to be met for any commodity. Nevertheless, compared to all other trade barriers discussed so far, logistic barriers are the largest for wood pellets, with 75% of all experts considering them a major or at least minor hurdle (see Fig. 4). Logistics were also seen by most experts as a barrier for liquid biofuels, though in the comments, respondents remarked that this was mainly the case for the supply-side, i.e. in many developing countries, such as South Africa and Indonesia. Bad roads, and insufficiently developed port infrastructure may be the prime reasons why exports of biofuels are commercially not viable at the moment.

On wood pellets, respondents remarked that many port facilities are designed for the import of high value goods and bulk commodities such as coal. Wood pellets have a lower value, and are difficult to handle and manage without proper infrastructure. In addition, the safety aspect may also play an increasingly important role. A Dutch trader mentioned that “permits for storage of wood pellets are for e.g. the Rotterdam area very difficult to obtain, which seriously limits large-scale use of wood pellets.”

4.6. Sanitary and phytosanitary measures

4.6.1. Literature review

For **liquid biofuels**, final products may face sanitary and phytosanitary (SPS) measures or technical regulations applied at borders. SPS measures mainly affect feedstocks which, because of their

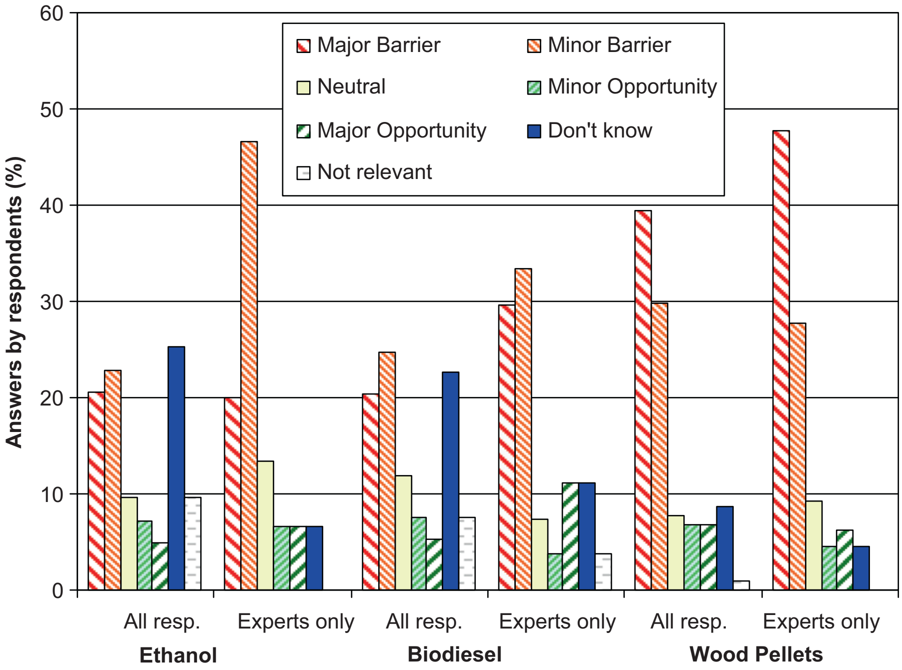

Fig. 4. Overview of questionnaire responses on logistical barriers.

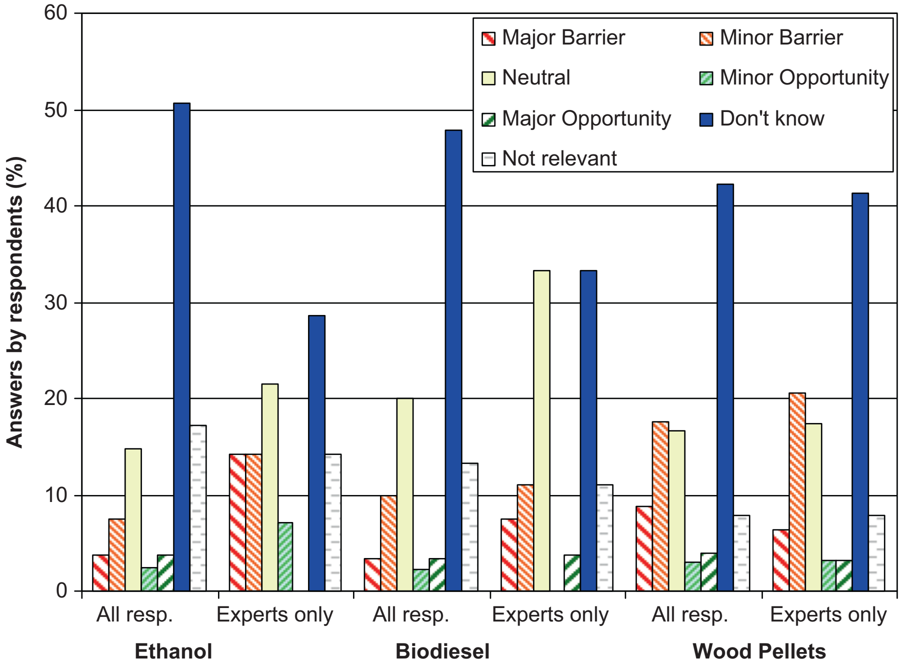

Fig. 5. Overview of questionnaire responses on phytosanitary measures.

biological origin, can carry pests or pathogens. One of the most common forms of SPS measure is a limit on pesticide residues. Even though pesticide residues are regulated mainly to ensure the safety of food and beverages, and are much less of a problem in biofuels feedstocks that will undergo thermal or chemical processing, customs agents nonetheless may have no other choice than to apply the same regulations to vegetative biofuel feedstocks as to crops destined for human or animal consumption, especially if they have no way of determining the product's end use. Meeting pesticide residue limits is usually not difficult, but on occasion has led to the rejection of imported shipments of crop products, especially from developing countries (Steenblik, 2007). For **wood pellets** no sanitary and phytosanitary measures have been found. But for example undebarked untreated round wood and chips from outside Europe are (with a few exceptions) not allowed and are inspected thoroughly for import into the EU (see also Heinimö and Alakangas, 2009). Similarly, agricultural residues which could be used either as fodder or for production of heat and electricity may currently be denied entry if they do not meet certain fodder requirements. These kinds of practices may be avoided when adequate technical/sustainability standards are in place.

4.6.2. Survey results

The respondents were asked whether SPS measures were a barrier to bioenergy trade. Perhaps the most striking observation from Fig. 5 that most respondents (including the experts) indicated that they did not know about any phytosanitary measures. This illustrates that for the three selected commodities, phytosanitary measures are not a barrier. Several respondents remarked that SPS in some cases may actually present an opportunity (e.g. for feedstocks that are unsuitable for the food chain to be converted into biofuel), and that in some cases raw materials (e.g. jatropha sees for biodiesel, or wood chips for wood pellet production) do face SPS measures.

4.7. Lack of clear bioenergy trade statistics

4.7.1. Literature review

A fundamental problem is that for many bioenergy carriers, several end-uses are possible, and thus it is hard to determine how much exactly is traded for energy purposes. A few biomass commodities traded almost exclusively for energy end-uses, e.g. ETBE (bioethanol), FAMAE (biodiesel or solvent), fuelwood and charcoal. These commodities have their own HS-codes, and therefore their trade can be monitored rather straightforward. But many agricultural commodities like cereals and oilseeds, animal or vegetal fats and oils (e.g. palm oil), which can all serve as feedstock for biofuel.[3] Thus, it is practically impossible for these trade flows to determine how much is traded of energy purposes, and estimates have to rely on crude assumptions and interviews with market parties. Furthermore, the HS harmonizes product codes at the six-digit level. For both ethanol and biodiesel, however, countries are using at the national level tariff classifications that go beyond the six-digit level of the HS in order to distinguish the different final uses of the products. Categorizing new bioenergy commodities (such as pyrolysis oil, pellets from various agricultural residues, torrefied pellets, etc.) are challenges for the future.

Furthermore, there is no consensus yet whether (liquid) biomass fuels should be considered as an agricultural or industrial good. Trade classification has important implications for countries' tariff reduction commitments as well as the national support schemes they can apply (EurActiv, 2009). Oosterveer and Mol (2010) underline that the WTO has not yet developed specific disciplines on trade in energy goods and therefore only the general WTO rules are applicable. They explain that the specific problem to determine the trade regime for biofuels concerns their classification. Bioethanol, which is considered an agricultural good, falls under the Agreement on Agriculture (AoA), while biodiesel is classified as an industrial good and falls subsequently under GATT. This implies differences especially as far subsidies are at stake. This differential treatment does not appear to be justified considering that ethanol and biodiesel are competitive products, since they can replace each other for certain uses, for example to power vehicles.

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[3] This raises the question whether trading of raw feedstocks should at all be considered 'bioenergy' trade. For example, if palm oil imported from Malaysia to the Netherlands, and then converted to biodiesel in the Rotterdam harbor, this will be counted as Dutch 'domestic' production of biodiesel. However, from an energy point of view, over 90% of the mass (and energy embodied in the biodiesel) was produced abroad (i.e. the carbon was fixed from the atmosphere in Malaysia).

Wood pellets are currently not included as separate category in the HS system, but fall under wood wastes. The joint UNECE/FAO working party on forest economics and statistics and other bodies have pointed out the need for some changes to the HS in order to show the role of wood in energy supply. The Inter secretariat Working Group (IWG) on forest sector statistics (FAO, Eurostat, ITTO) will attempt to have wood pellets added to the HS 2012 revisions (UNECE Secretariat, 2008). In the EU, since the 1st of January 2009, official export and import figures on pellets are published by Eurostat using the product code "44.01.3020", defined as "sawdust and wood waste and scrap, agglomerated in pellets" (Sikkema et al., accepted for publication).

4.7.2. Survey results

As shown in Fig. 6, the issue of lacking trade statistics was only considered a minor issue for ethanol (for which indeed general statistics exist), a somewhat bigger issue for biodiesel, and a major issue for wood pellets.

Specifically for biodiesel, the EBB pointed out that until "2008, there was no specific CN code at EU level for biodiesel imports. This made the tracking of biodiesel imports before 2007 rather difficult. Now that a specific CN code 3824 90 91 has been provided to cover imports of biodiesel (FAME), there is still a concern that some traders may still continue to use the residual code 3824 90 97 when entering biodiesel in the EC, notably to circumvent the EU duties on US biodiesel." More generally, the EBB pointed out that current customs definition/classification of biodiesel (on EU or World Customs Organization level) covers only currently traded biodiesel ("fatty acid methyl ester"). Next generation biodiesel technologies (e.g. Fischer-Tropsch Fuels) remain classified in chapter 27 of the harmonized nomenclature. It seems particularly important that future negotiations on biodiesel customs classification takes into account the latest technological developments (also for instance algae biodiesel) and promotes a classification/definition that takes full account of these different fuels.

For wood pellets, several respondents pointed out that the lack of decent statistics on production, trade and consumption makes investment decisions riskier, will limit capital flows, and it will become difficult to continue to develop policies for increased production and use of bioenergy in competition with other renewable energy sources. Other market actors however pointed out that market intransparencies may on the short term also create opportunities for trade.

4.8. Other barriers

Next to the barriers discussed in the previous sections, respondents also had the opportunity to point out additional barriers (see Junginger et al. (2010) for all answers). Many of these comments were related to the barriers already addressed earlier in the questionnaire, e.g. logistical issues, the danger of multiple and fragmented sustainability certification systems, and policies protecting national markets. A few respondents raised also the following concerns:

- local control of export transactions by large multinationals, limiting exports of small-scale producers as they have to abide to the multinationals' export regulations and restrictions;
- difficulties to find buyers and sellers of biomass, as these markets are often still very immature;
- improving the physical properties of biomass (e.g. through torrefaction) to improve handling and long-distance shippings;
- increasing administrative burdens and institutional barriers;
- lack of transparent wood pellet prices;
- many wood pellet market actors remarked that varying subsidy schemes in different countries create "artificial" and unstable trade flows and an unlevel playing field.

Furthermore, as a final remark, a few respondents stated that they believed in "local for local", i.e. that biomass should first and foremost produced be before any biomass imported (possibly even if available at lower costs). To achieve this some proposed that policies should in first instance stimulate local production before any support is given to imported biomass.

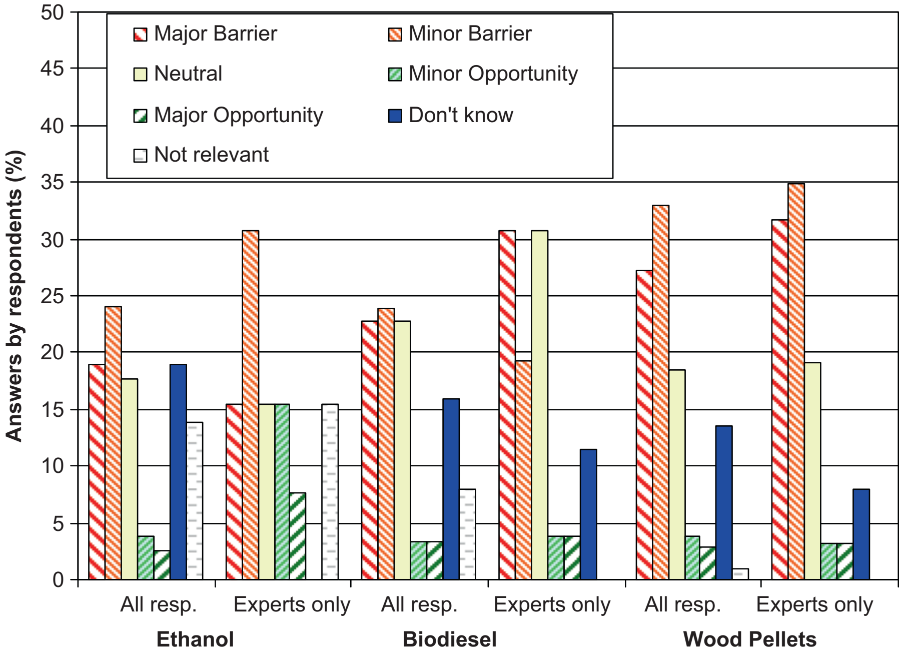

Fig. 6. Overview of questionnaire responses on clear bioenergy trade statistics and lack of global classification.

4.9. Opportunities for biomass trade

After the extensive effort to obtain an overview of barriers for bioenergy trade, last but not the least, respondents were also asked what they thought to be the biggest opportunities and drivers for international bioenergy trade. The results are shown in Fig. 7.

As shown in Fig. 7, high oil prices and strong GHG emission reduction policies are most important for all commodities investigated. Not surprisingly, high coal prices were only seen an opportunity for wood pellets (as about half of the global wood pellet production is used to replace coal in power plants). However, the importance of coal prices for wood pellet trade was deemed less of an opportunity (only 50% of the experts thought so) compared to high oil prices as driver for biodiesel (more than 70%) and especially ethanol (more than 90%).

Strong policy support for liquid biofuels (for ethanol and biodiesel) and for electricity and heat from biomass (for pellets) was also deemed very important conditions for further growth of international bioenergy trade. Global or country-specific initiatives (not initiated by governments) aimed at GHG emissions reduction were deemed less important drivers for biomass trade.

Also energy-security concerns, rural development and the search for new markets for agricultural commodities were only seen as minor drivers. The geopolitical concerns were deemed more important drivers for ethanol and biodiesel import (as coal is less of concern for the security of supply than oil). Rural development were seen as the largest opportunity for biodiesel (probably because of the small-scale initiatives to produce it from small-scale Jatropha plantations), and again the least for wood pellets.

Also somewhat remarkable is the fact that the experts are in almost all cases more optimistic on the opportunities for "their" commodity than the average of all respondents. In the case of high oil prices as driver for ethanol trade, this difference is 90% for ethanol experts vs. 50% for all respondents.

Next to these opportunities, respondents were also asked whether they saw any other factors that might create opportunities for increasing biomass trade (see Junginger et al., 2010). These included high prices for natural gas (in addition to oil and coal), using biomass from new areas with abundant feedstock reserves (e.g. Russia, Africa, Latin America and Australia), payment for ecosystem services (of which biomass could be one) and lower shipping costs.

5. Discussion and conclusions

5.1. Discussion of the questionnaire response

With 141 participants, the overall number of respondents was somewhat lower than originally anticipated, yet sufficient to identify trends and draw meaningful conclusions. More than 50% of the respondents worked in the industry, and the remainder of respondents was divided over NGO's, academia, governments and other backgrounds, which is a good precondition to obtain views from different angles. Wood pellet experts constituted the largest expert group with 70 experts, followed by smaller groups of biodiesel and ethanol experts. The smallest group (18 respondents) indicated that they only had general knowledge. It has to be pointed out that all respondents were free to qualify themselves as experts, while we had no means to check their actual level of expertise. However, from the many additional comments and explanations, it became clear that many of the respondents had in-depth knowledge of the topics.

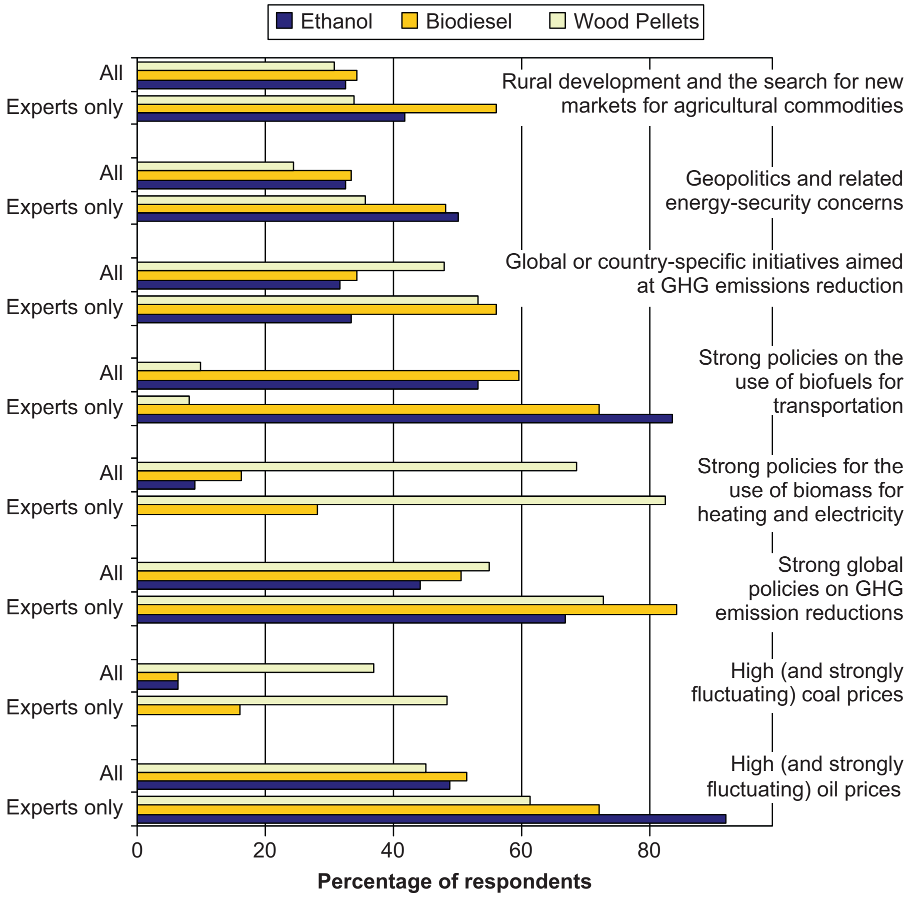

Fig. 7. Opportunities for bioenergy trade according to the respondents.

Due to the limited amount of response, it was not possible to differentiate further between stakeholder groups, e.g. to investigate whether bioethanol experts from industry had strongly differing views than bioethanol experts from NGO's or academia. Also, the geographical coverage was not ideal, as more than two-thirds of all respondents were based in Europe. This was somewhat expected, as the questionnaire was disseminated mainly through the network of the Task 40 members (of which 10 out of 14 are situated in Europe). We attempted to compensate for this by sending the invitation to the questionnaire to another 1000 recipients, of which a significant part was based in Latin America, Asia and Africa (we aimed for 80% market coverage of biomass producers and traders for each region), but the response was relatively low. This may partially be due to the fact that the questionnaire was only in English, and could only be completed over using the internet. Thus, there is a chance that the views of (mainly exporting) countries in Latin America, Asia and Africa are underrepresented. Where possible, we did include the views of respondents from these regions in the discussion of each barrier.

5.2. *Main barriers and drivers identified and policy recommendations*

As a first and general observation, it was clear from the start that biomass commodities are rather heterogeneous in terms of production methods, chemical and physical composition and final end use, and thus barriers and drivers for their use and trade vary significantly. Yet, a number of general barriers and opportunities for bioenergy trade were identified.

Regarding *import or export tariffs*, tariffs for ethanol have been established for several decades (as ethanol has also been traded for other purposes than fuel). For biodiesel, regular import tariffs have been in place for a number of years, but the anti-dumping and countervailing duties of the EU directed at US biodiesel imports have only been fairly recently. In the RED, the EC states that it aims to meet the European biofuels targets using a combination of domestic production and imports of biofuels, and to this end, will propose "…relevant measures to achieve a balanced approach between domestic production and imports…". With the increasing production volumes in South-East Asia, Latin America, the US and the EU, it is possible that trade volumes from producers in developing countries may further increase, which may lead to further competition with domestic European producers. This could lead to further escalating trade conflicts—for example the EBB is currently investigating the possibilities for further actions against Argentines differential export tax (EBB, 2009b). Instead, we would recommend that policy makers from the major producing and consuming regions in developing and developed countries explore the possibilities for joint international trade agreements to enable developing countries to produce biofuels for export, and to allow developed countries to meet their bioenergy (and renewable energy) targets. As a start, import tariffs for biofuels could generally be reduced or abolished. Indeed, the competitiveness of domestic biofuels in industrialized countries depends by and large on the fact that they are shielded by subsidies and import tariffs. Such instruments offset lower production costs in other countries and represent a significant barrier to international trade, as well as a tool to guarantee a captive market for domestic biofuels producers.

As solid biomass is mainly destined to produce renewable electricity and heat (which can also be produced by many other technologies), the chances seem smaller that tariff barriers are introduced for solid biomass commodities, although indirect effects (such as the export tariff of Russian raw wood to Finland and the Baltic states) may still have an impact. Another important aspect is that so far, solid biomass is mainly based on by- and waste products from agriculture and forestry, while liquid biomass have a higher value and are almost exclusively produced from food and fodder crops.

Regarding the introduction of *technical standards*, the overall impression we received from respondents is that the gains outweigh the losses—this was especially the case for wood pellets. The advantages of a uniform product were deemed high. The fear that technical standards might be used to ban especially biodiesel based on soy or palm oil from European markets was not a major concern of the respondents, as large amounts soy-based biodiesel have been imported to the EU in past years. Thus, overall, the introduction of technical standards should probably be seen as an opportunity rather than a barrier. The fact that already the major producing regions have started to compare (and possibly align) their technical standards for ethanol and biodiesel is a sign that international policy cooperation may lead to new opportunities for international bioenergy trade. For the future, we recommend that policy makers anticipate the development of new bioenergy commodities (such as Fischer-Tropsch diesel or torrefied biomass pellets) and recognize the necessity to (timely) develop technical standards for them, and to include them in global trade statistics.

It is perhaps still too early to say what the impact of *sustainability criteria* may be on international trade. On the one hand, respondents clearly recognized that there is a need to substantiate the sustainable production of (especially liquid) biofuels. On the other hand, many respondents mentioned that there is so far no consensus on what should be considered sustainable production, and how this should be certified. In the end, it will probably depend on whether one (or a few) generally accepted systems will become commonplace, and whether these systems are workable and affordable. However, if the current mushrooming of new initiatives continues, it will likely become a burden for international trade rather than a stimulant. Also the costs for implementing measures to meet the sustainability criteria may significantly worsen the economic competitiveness of sustainably produced biofuels compared to fossil fuels (see also Sikkema et al., submitted for publication; Smeets et al., 2008; Smeets and Faaij, 2010). Again, a dialog of policy makers from the EU, US and major producing regions to come to internationally accepted (minimal) sustainability requirements for liquid (and possibly also solid) bioenergy commodities could create new opportunities for sustainable bioenergy trade. The views of European stakeholders towards such a harmonized system are further described in van Dam and Junginger (submitted for publication).

As pointed out by some respondents, *logistics* are "just another issue that every commodity faces", and in that sense not especially related to biomass commodities. However, in particular solid biomass commodities are currently often characterized by a low energy density and a relatively low value, and they have to be handled with care. This makes the costs for logistics sometimes higher than the production costs of the biomass delivered at the farm/factory gate, and can thus be a prohibitive factor for international trade. While policy makers may play a role in overcoming logistical obstacles (e.g. by building better roads and other infrastructure), dedicated investments for e.g. wood pellet handling equipment will probably have to come largely from the industry itself.

Regarding other barriers, *phytosanitary measures* were not deemed an issue for the three commodities investigated in this study, but it is likely a major issue for wood chips and other untreated solid biomass, requiring more detailed investigation in the future.

Finally, concerning the *main drivers for bioenergy trade*, the obvious most important factors were fossil fuel prices (especially oil prices) and policy support, which can be subdivided in support for renewable electricity, heat and transport fuels, and strict policies to curb GHG emissions. Interestingly, these two factors are basically the same main drivers for the trade of all commodities investigated, while the main barriers are often commodity dependent. This can be explained given the different geographical production regions, physical properties and (end-) uses.

Concluding, to overcome some of the barriers, specific actions will be required by market parties and policy makers. As pointed out above, import tariffs for biofuels could be reduced or abolished, linked to multi-national trade agreements and harmonization (including provisions on technical standards and sustainability requirements) which might provide the necessary preconditions for further sustained growth of international bioenergy trade.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2011.01.040.

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